ORIGINAL ARTICLE

The performance implications of pharmacy information system at the university teaching hospitals of Shiraz, Iran: Cluster approach

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ABSTRACT

Pharmacy information system (PIS) is becoming vital in assisting pharmacists to do their responsibilities. The aim of this study was to identify the current PIS implications in teaching hospitals affiliated with Shiraz University of Medical Science. This cross-sectional study was conducted in teaching hospitals affiliated with Shiraz University of Medical Science over the year 2016. Data were collected by observing the PIS as well as interviewing its users based on the researcher-made checklist. The checklist was prepared based on reviewing the Persian and English literature and its content validity was approved by the experts. To determine the reliability of the checklist, inter-rater reliability was used. Data were analyzed using $SPSS_{16}$, and hospitals were clustered using SK-means method. In this study, the least conformity to the standards was shown in smart clinical features (4.54%), pharmaceutical companies' relationship (32.6%), and optimization of drug therapy (34.6%). In contrast, the highest conformity to the standards was shown in reporting capabilities (77.3%) and entry information and input (70.4%). Medication stock checking and optimization of drug therapy were effective features that have made a distinction between hospitals and lead to 95% variance between clusters. Based on the results, the current PIS design pays less attention to clinical features. Besides, clinical information for pharmacists and outside organization relationship were not provided by the current system. Thus, emphasis should be placed on the implementation of corrective actions to eliminate the current system's deficiencies.

Key words: Capability, pharmacy information systems, pharmacy practice

INTRODUCTION

Health information technology is becoming a vital tool for pharmacists. It is also integrated with the pharmacy operation and management which leads to lower possible harms to patients over the medical treatment procedures.[1] Although pharmacists are aware of the pharmaceutical care management, they have not accessed the information related to monitoring drug usage and its management.[2] The core functions of the pharmacy information system (PIS) included outpatient and inpatient order entry, dispensing and purchasing management, and pharmacy stock.[3] Other activities such as reporting, clinical monitoring, intervention

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management, administrating drugs, connection with other systems, transferring information, and financial statement management should be also supported by PIS.[4] PIS makes healthcare providers aware of potential drug interactions and overdose through the smart alert and fast clinical information access.[5] According to the recent studies, designing PIS in Iran is semi-computerized,[6] in which prescribing and administrating drugs as a way to support practitioners have not been noticed.[7] Most pharmacies' software has numerous deficiencies such as lack of ability to assess drug interaction, connection to the internet, and access to drugs information banks.[8] Kazemi *et al*. focused on a multidimensional evaluation of the PIS. They found that PIS is designed to support financial activities, while clinical features and patient safety were given less attention.[9] Isfahani *et al*.'s study indicated that most of the PIS in Isfahan hospitals was semi-computerized and had the least conformity to the system (input, process, output) standards.[10] Thomsen *et al*. investigated the PIS in 18 European and non-European countries. They found that the major application of PIS was concerned with the features such as dispensing drugs and it is followed by providing consultancy in drug usage and dose determination.[11] Lack of functionality practices in information systems can lead to not understanding of their potential and actual benefits. Designing and setting up information systems are costly, which is even more, highlighting the importance of these systems assessment. Thus, to get the most out of information systems, we should compare them with standard criteria. In this vein, the principle objective of this study is to clarify the PIS practice features and find its strengths and weaknesses.

MATERIALS AND METHODS

This cross-sectional study was conducted in 12 teaching hospitals affiliated with Shiraz University of Medical Science over the year 2016 to investigate the PIS. Data were collected by means of the researcher-made checklist. The checklist was prepared based on the literature review and guidelines of the American Society of Health-System Pharmacists, the Pharmaceutical Society of Australia, and the National Association of Pharmacy Regulatory Authorities of Canada plus the Ministry of Health of Iran PIS checklist. The researcher-made checklist included eight main practice features and 129 subordinate features. Its content validity was approved by two pharmacists and faculty members of health information technology. To determine the reliability of checklist, inter-rater reliability was used that assessed by test re–test method through Pearson correlation (r = 0. 75) that indicates fair reliability.

This checklist was prepared to get the better understanding of practice features of PIS, which includes yes, no, and consideration choices. These choices were scored by assigning weights of +1 if the practice feature existed or choice yes selected and weighs zero otherwise. Further, in data clustering report, if clusters in any key features got the score which is the nearer to one, the better they seem to be in that practice feature. One of the researchers went to the information system unit directly and observed the software and at the same time interviewing those pharmacies who were qualified in the area of the software helps the researchers achieve the system capabilities. To confirm direct observation and interviews with pharmacies, the researchers referred to the hospital's information system supervisors and rechecked the data.

Data were analyzed using SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. (Chicago, SPSS Inc.). To indicate the effective capabilities that made a distinction between hospitals, SK-means method was utilized. This method clusters data based on the least distance between each data and the cluster center (mean). In this study, considering limited data, we applied the SK-means method using R: A Language and Environment for Statistical Computing. 2011. Vienna, Austria: The R Foundation for Statistical Computing. Hence, the data cluster in K groups which are acquired the least sum-of-squared distance between data and the cluster center. Actually, from the data points, distinct groups were made in which average distance between the data and the cluster center was the lowest.

RESULTS

Overall results concerning the PIS are outlined in Table 1. This table indicates that the least conformity to the standards was shown in smart clinical features (54.4%), pharmaceutical companies' relationship (32.6%), and optimization of drug therapy (34.6%). In contrast, the highest conformity to the standards was shown in reporting capabilities (77.3%) and the entry information and input (70.4%).

Figure 1 outlines the overall PIS scores in each hospital. Based on this, hospital A has the highest conformity to the standards and hospital L has the lowest conformity scores.

Figure 2 depicts a graph concerning the relative importance of the capabilities in hospitals clustering. Based on this,

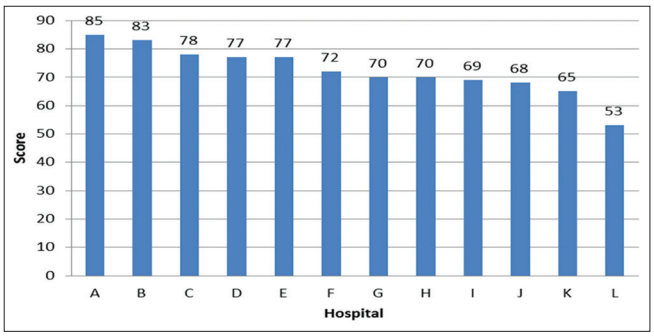

Figure 1: Comparison of the sum of pharmacy information system scores in teaching hospitals

Table 1: Capabilities of pharmacy information system

Hospitals	Capabilities of pharmacy information system														Total score (129)	Percentage
	Reporting		Pharmaceutical stock checking		Calculating and processing		Input and information entry		Communication with pharmaceutical companies		Optimizing drug therapy		Smart clinical capability		Other capabilities			
	Score (33)	Percentage	Score (13)	Percentage	Score (22)	Percentage	Score (25)	Percentage	Score (11)	Percentage	Score (7)	Percentage	Score (11)	Percentage	Score (7)	Percentage		
A	29	87.9	10	76.9	12	54.5	21	84	6	54.5	2	28.6	1	9.1	4	57.1	85	65.9
B	25	75.7	6	46.1	14	63.6	19	76	7	63.6	7	100	0	0	5	71.4	83	64.3
C	28	84.8	10	76.9	13	59.1	16	64	6	54.5	2	28.6	0	0	3	42.8	78	60.5
D	29	87.9	7	53.8	14	63.6	19	76	2	18.2	0	0	0	0	6	85.7	77	59.7
E	28	84.8	5	38.5	9	40.9	20	80	0	0	7	100	3	27.3	5	71.4	77	59.7
F	25	75.7	7	53.8	8	36.4	17	68	5	45.4	5	71.4	1	9.1	4	57.1	72	55.8
G	26	78.8	7	53.8	13	59.1	17	68	2	18.2	0	0	0	0	5	71.4	70	54.3
H	26	78.8	5	38.5	13	59.1	18	72	4	36.4	0	0	0	0	4	57.1	70	54.3
I	22	66.7	6	46.1	12	54.5	18	72	3	27.3	4	57.1	0	0	4	57.1	69	53.5
J	25	75.7	9	69.2	11	50	14	56	1	9.1	2	28.6	1	9.1	5	71.4	68	52.7
K	23	69.7	4	30.8	11	50	19	76	3	27.3	0	0	0	0	5	71.4	65	50.4
L	20	60.6	5	38.5	9	40.9	13	52	4	36.4	0	0	0	0	2	28.6	53	41.1
Mean	25.5	77.3	6.75	51.9	11.6	52.7	17.6	70.4	3.58	32.6	2.42	34.6	0.5	4.54	4.33	61.85	72.25	56

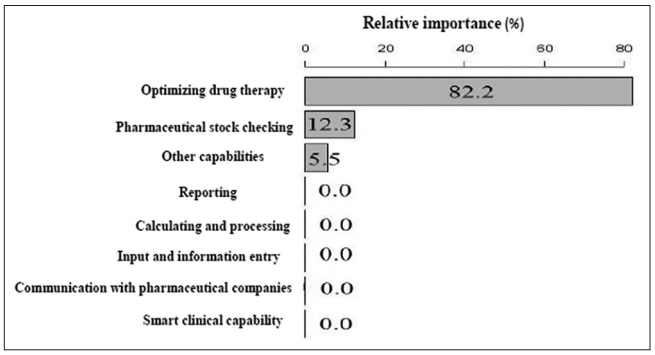

Figure 2: Relative importance of features in hospitals clustering

optimization of drug therapy, medication stock checking, and other features were effective features that have made a distinction between hospitals. Optimization of drug therapy was the most important features that caused 82.2% variation in between other clusters. Following that, medication stock checking (12.3%) and other features (5.5%) were of importance.

The rest of the features did not have the effective role in between hospitals; in other words, these features were identical in various hospital [Figure 2].

Almost 95% variations between clusters were caused by optimization of drug therapy and medication stock checking. As can be seen in Figure 3, we clustered hospitals in four groups. Hospital L was placed in Group 1. Group 2 contained hospitals H, D, G, K, I, and F. Hospitals E and B were placed in Group 3, and finally, Group 4 contained hospitals C, J, and A.

We identified that hospital L in Group 1 only utilized medication stock checking feature. In Group 3, optimization of drug therapy got more attention compared to medication stock checking, while in Group 4, medications stock checking was of importance. Each hospital in Group 2 has gotten almost the same attention on both practice features. Furthermore, Figure 3 indicates that the capability of drug stock checking in cluster 1 is <0.4 and in the capability of optimizing drug therapy it is next to 0. In cluster 2, the capability of optimizing drug therapy is varied between 0.4 and 0.7 and the capability of drug stock checking is varied between 0.3 and 0.55. In cluster 3, the capability of optimizing drug therapy is next to 1 and capability of drug stock checking is <0.5; finally, in cluster 4, the capability of drug stock checking varied between 0.7 and 0.8 in contrast with the capability of optimizing drug therapy that is near 0.3

DISCUSSION

Our main findings in assessing systems in the reporting section showed that the majority of practice feature existed in all systems. Systems' deficiencies in this feature mostly

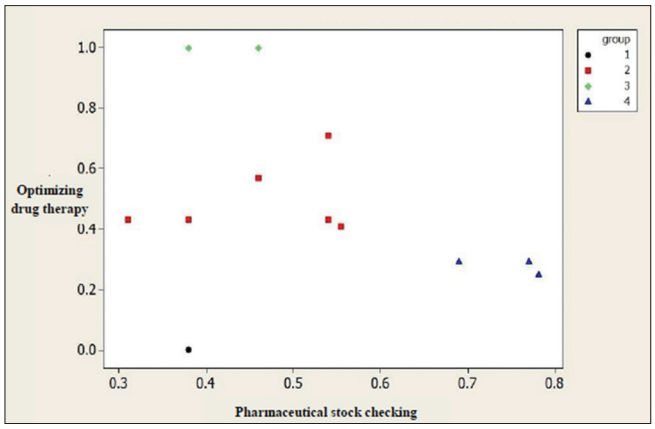

Figure 3: Clustering hospitals based on medication stock checking and optimization of drug therapy

included providing report based on each physician, drug functions, patient drug history based on each year. PIS should track patients' drug history and store demographic information of physicians who prescribe medication and drug information such as dosage and drug effectiveness.[12] In this regard, only a quarter of systems had the possibility to provide the frequency report concerning the ward's emergency requirement of drugs, drug manufacturers, and expired date and defined consumption period of drugs. Asadi *et al*.'s study revealed that only 7.6% of pharmacies' systems had the possibility to provide a frequency report concerning emergency drugs requirement of various wards and 15.3% of them can provide the drug manufactures frequency report.[6] This finding is almost parallel to those of the current study.

Drug interaction leads to cost imposition, the higher length of stay in the hospital, and even death.[4] In this regard, PIS should also provide a drug interaction report to lower the medication error.[6] Malone *et al*. showed that the majority of pharmacies' software in the United States has not had a capability to recognize and report drug interaction.[13] In the current study, we could not also find this feature.

Findings related to medications stock checking indicated that half of the systems possess lower than 50% of that capability. PIS should support four main features, including entry inpatient and outpatient orders, dispensing, supply management, and purchasing.[3] The most common systems' deficiencies in medication stock checking included warning before the medication expiry date, documentation regarding how and where to maintain drugs in the warehouse, identifying the thresholds stock level, purchasing alert order whenever the inventory level falls below the threshold stock level, medication inventory sharing in between other pharmacies, and providing purchasing proposal automatically whenever it reaches order point or based on the pharmacy's need. In a study done by Sadoughi *et al*., vital components of PIS in the majority of users perspective contained features such as warning before the drugs expiry date, record information concerning how and where to maintain medication in the warehouse, and awareness ability whenever a shortage seen in the inventory and sharing information in between pharmacies.[14] Kazemi *et al*. evaluate five PISs and found that all of them have had to identify the threshold level of inventory feature.[9] Such differences in the current study's findings could be attributed to the fact that features existed in a symbolic way, yet they haven't done the related functions.

In the measurement and process features, the possibility of calculating drug dose, patient drug usage based on diagnosis, volume of injected medication, nutrient receiving through injection, average number of drugs prescribed, and its percentage with the generic name had the lowest conformity to standards. In Asadi *et al*.'s study, only 30.7% of hospitals possessed dose calculation feature.[6] Considering that drug dose calculation is one of the core components of medication care and the occurrence of any medication error can threaten patient safety.[15] Moreover, all hospitals' PIS under investigation failed in calculating the percentage of the prescription with at least one antibiotic, calculating the percentage of the prescription with at least one injected medication, and calculating the percentage of prescription based on the drug manual. These findings correspond with Asadi *et al*.'s study.

PIS could have three databases which involved patients, drugs, and prescriber. These databases lead to facilitate prescription management affairs and drug dispensing.[16] By investigating systems in terms of recording the information and output, we found that more than half of the systems were without features such as recording and retrieval of address and telephone number of prescriber in prescribers' database plus recording and retrieval of address and telephone number of patients in the patient's database. Another feature of PIS is recording the patient drug history, recording allergies, and other physiological characteristics of patients.[17] Accordingly, in the majority of hospitals' PIS under investigation, features such as the conditions in which patients use their medications, drug allergies, drug interaction, patients' nutrition status, and their physical functions were not recorded. Besides, other features such as recording and retrieval of chronic conditions, patients' prescription profiles, and their compounded drugs were also not existed in most of the hospitals' PIS. In this vein, Saghaeiannejad-Isfahani *et al*. found that medication error status, drug interaction, adverse drugs reaction, and challenges related to drug usage were far from its optimal level.[18] In addition, El Mahalli *et al*., by assessing PIS in three hospitals, found that using the clinical decision support and drug allergies alerts was at the minimum level.[5] Moreover, in Asadi *et al*.'s study, patients' clinical information was also not recorded.[6]

The relationship between hospital information system and different departments in pharmaceutical companies such as marketing, pharmaceutical research, and development, product introduction, monitoring product after sales, and medication quality has an influential effect on the drug care improvement and drug usage management.[19] Based on this, our findings showed that the majority of systems with respect to this feature failed in recording the drug order through systems. In line with our findings, Asadi *et al*. found that none of the PIS enabled order drugs electronically.[9] Thus, for the sake of providing the efficient drugs services, the electronic relationship between pharmacies and pharmaceutical companies should be provided.[20]

With regard to the optimization of drug therapy, we found that only a quarter of systems enabled to revise drug plan, choose alternative drugs, and document reasons of revising the drugs' plan. Goldberg *et al*. concluded that if pharmacists revised the drug orders through the system, it would lower the potential errors, time, and cost.[21]

With regard to smart clinical features, none of the systems enabled to define adverse drug reactions in the basic table notify if prohibited drug usage for patients were requested, drug–drug intersection, drug–disease interaction, and drug–food interaction; moreover, they have not had a supporting system in diagnostic decision-making. The results of Kazemi *et al*.'s study showed that designing the PIS reflected the least attention which was given to the both patient safety and prescription management.[9] Similar results were found in El Mahalli *et al*.'s study which indicates that application of decision support system was the least possible amount.[5] In contrast with our finding, Hines *et al*.'s study indicated that PIS equipped with the drug interaction alert and prohibiting drug usage alert.[22]

Outcomes of investigating other features showed that the rate of barcode technology usage in hospitals' pharmacy was more than radio-frequency identification (RFID) technology; it may be derived from the higher cost of RFID compared to barcode technology. RFID leads to cost saving, improving patient safety and promoting effectiveness in supply chain management.[23] Based on Sadoughi *et al*.'s study, 67% of managers and users disagree with the implementation of RFID technology in pharmacy.[14] It is worth mentioning that barcode technology leads to a less errors in drug usage.[24] Pedersen *et al*. by assessing the pharmacy practices contained dispensing and administration in the hospital settings found that 9.4% of hospitals took advantage of barcode technology and the trend of using this technology is on rising.[25]

CONCLUSION

Finding the system deficiencies was a key point on the implementation of corrective actions and providing crucial future implications. Findings showed that the current emphasis on designing PIS was placed more on the pharmacy's management rather than providing clinical information for pharmacists and outside organization relationship.

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Conflicts of interest

There are no conflicts of interest.

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